THE PROGRESSIVE FISH CULTURIST

NEWS AND VIEWS FROM MANY SOURCES ON PRACTICAL HATCHERY PROBLEMS

ISSUED BY THE

U. S. DEPARTMENT OF COMMERCE
DANIEL C. ROPER, SECRETARY

BUREAU OF FISHERIES
FRANK T. BELL, COMMISSIONER

FEBRUARY - MARCH 1938

WASHINGTON

TABLE OF CONTENTS

Page

POND Rearing of Wall-eyed Pike, by E. B. Speaker 1
SUGGESTIONS on Stream Improvement, by Osgood R. Smith 6
NOTES on Warm-Water Fish Culture, by C. F. Culler 19
CORRECTION and Notice of a New Publication 24
COMMENTS From Our Readers:
Feeding Trout in Streams after Planting, by J. P. Snyder 25
Water-Dissemination method for Feeding Fish by Means of Water Distributing Pipe Line System, by Fred H. Glenny 26
Suggestion for a Fish Grader, by K. E. Morton 29
Simple Method of Measuring Volume of Fish, by G. Clifford Carl 31
REVIEWS:
Hager, Franz: Use of Electricity in Fishing of Wild Streams, by David S. Shetter 32
Hoover, Earl E.: Experimental Modification of Sexual Cycle in Trout by Control of Light, by R. L. Carson 34
French, C. A.: Fish Conservation Advanced in 1937, by R. L. Carson 35

THE PROGRESSIVE FISH CULTURIST

A SERIAL memorandum published occasionally for the advancement of Federal, State, and private fish culture and fishery management in fresh waters.

Editor

Elmer Higgins, Chief, Division of Scientific Inquiry, U. S. Bureau of Fisheries.

Associate Editors

Dr. H. S. Davis, In Charge, Aquicultural Investigations, U. S. Bureau of Fisheries.
Professor Lauren R Donaldson, School of Fisheries, University of Washington.
Dr. A. S. Hazzard, Institute for Fishery Research, Michigan Conservation Department.
M. C. James, Assistant Chief, Division of Fish Culture, U. S. Bureau of Fisheries.
Dr. A. H. Wiebe, Biological Readjustment Unit, Tennessee Valley Authority.
Dr. Louis E. Wolf, New York Department of Conservation.

APPLICATIONS for this memo, which is distributed free on regular mailing lists, should be addressed to the Commissioner of Fisheries, Washington, D. C. Contributions for publication are welcome.

While a certain amount of editorial selection of material is exercised, the U. S. BUREAU OF FISHERIES DOES NOT NECESSARILY ENDORSE AND IS NOT RESPONSIBLE for the statements of facts nor for views and opinions published herein.

3407

THE PROGRESSIVE FISH CULTURIST

NEWS AND VIEWS FROM MANY SOURCES ON PRACTICAL HATCHERY PROBLEMS

ISSUED BY THE

BUREAU OF FISHERIES, U. S. DEPARTMENT OF COMMERCE

Memorandum I-131 Washington, D. C., February-March 1938 No. 36.

POND REARING OF WALL-EYED PIKE 1/

By E. B. Speaker,
State Superintendent of Fisheries
Iowa State Conservation Commission
Des Moines, Iowa.

YELLOW PIKE PERCH, or wall-eyes, have been artificially propagated in Iowa for many years. Although the results obtained from planting these fishes in the fry stage have been quite favorable, it was believed that if they could be reared to larger size, their chance for survival under more or less adverse conditions, would be greatly increased.

In the spring of 1927, Center Lake, a 250-acre lake, located in Dickinson County, was stocked with 25,000,000 wall-eyed pike fry after the game fishes and 236,000 pounds of coarse fishes had been removed. The lake at that time had a maximum depth of 12 feet. The shoreline was a combination of boulder rock and sand, and the bottom was blue clay with a deep over deposit of silt. The aquatic vegetation consisted primarily of narrow-leafed pond weeds, including Potamogeton pusillus, P. pectinatus, and a considerable amount of Naias flexilis. Blue-green algae, including Aphanizomenon, Microcystis and Anabaena, were present and their growth was greatly increased by the addition of nitrogenous commercial fertilizers which were added to produce an abundance of zoo plankton.

Fish food organisms, such as Rotifers, Copepods, Daphnia, and Ostrocods, were present in large numbers and increased tremendously during the first season. A considerable amount of midge and damsel fly larvae was also available for consumption.

1/ Presented before the Mid-West Fish and Game Conference, Sioux Falls, S. D. June 12, 1937.

A year later, during the month of May, 1928, the lake was seined with 2,000 feet of three-quarter inch mesh drag seine and 1,502,000 yearling wall-eyes were removed. These fishes averaged from four and one-half to six inches in length.

These results were gratifying since, to our knowledge, this was the first successful attempt to rear large numbers of pike to fingerling length in the United States.

Center Lake was again stocked in 1928 with 25,000,000 fry and of this number only 372,500 fingerlings were recovered.

Apparently the commercal fishermen had not previously succeeded in removing all of the bullheads, for during the summer of 1928 hundreds of schools of bullhead fry were observed. Although the Department made a desperate effort to remove the bullheads, it was virtually impossible. Stomach analysis of the adult bullheads revealed that a considerable portion of ther diet consisted of young wall-eyed pike and fathead minnows which had been introduced as forage fishes. The lake was abandoned as a pike nursery in 1929 and has since served as one of the most important bullhead production areas in the state.

In 1929 Diamond and Welch lakes, also in Dickinson County, were cleaned of all species of game and coarse fishes and stocked with pike fry. These lakes are similar biologically to Center Lake, except that they are smaller in size and more shallow. Diamond Lake is approximately 150 acres and Welch Lake is 50 acres. Both lakes have a maximum depth of about six feet.

During the pioneer work of producing wall-eyed pike to fingerling size, we were of the opinion that they should be held in the rearing lake for a period of one year in order to produce a suitable size for stocking.

In 1931, however, we found our two nursery lakes were not of a sufficient depth to carry an adequate supply of dissolved oxygen under adverse conditions during the winter months. We found that, during severe winters, the oxygen in these lakes would drop to less than .05 p.p.m. which was below the lethal point for fish life and that our losses due to asphyxiation were enormous.

Consequently, then, for the past five years we have made a practice of stocking the fry in May and removing the fingerlings during the months of October and November.

We are hatching 72,500,000 fry at our Spirit Lake hatchery annually. The total cost of this production is $2,698.71 per year, inclusive of all expenses and the cost of securing eggs and hatching operations. The brood fishes are captured on their spawning beds from sundown to four o'clock the following morning in 2-inch bar measure gill-nets. Crews of two men each operate three 200-foot gill-nets. These nets are checked every two or three hours. The eggs and milt are taken from the ripe fishes at the camps and the green ones transferred to the hatchery where they are held in wooden tanks until ripened. The cost of producing fry at this station is $37.19

Average growth of pike perch in Diamond Lake, Dickinson County, Iowa, during 1937. Fry released in lake May 2, when 7 days old; smallest fingerling taken June 7 and the others, from top to bottom, on June 19, 30, July 10, 21, 31 and August 10. Actual size as shown. (Photo by Dr. George Huff.)

per million or 3.7¢ per thousand.

During the 1937 season 2,344 males and 1,696 females were used to produce 116,200,000 eggs. According to our calculations 67½ percent, or 72,500,000 eggs hatched. The cost of obtaining the eggs alone, exclusive of hatching operations, maintenance of buildings, etc., was $884.50.

The following tables show the results obtained from Diamond and Welch lakes for the past five years, not including the cost of the fry:

DIAMOND LAKE

Year	Stocked	Removed	Cost	Each (cents)	Percent Survival
1932	3,000,000	161,000	$3,712.91	2.304	5.36
1933	2,500,000	357,250	4,036.16	1.13	14.28
1934	2,000,000	50,242	1,506.79	3.0	2.50
1935	3,000,000	169,500	904.74	.532	5.65
1936	3,000,000	158,066	1,168.86	.738	3.97
1937	3,000,000	---	---	---	---

WELCH LAKE

1932	1,000,000	140,425	$ 1,462.84	1.04	14.0
1933	900,000	78,000	742.1	.95	8.68
1934	None	None	430.96[1]	---	---
1935	None	None	8.92[1]	---	---
1936	2,500,000	45,493	759.54	1.669	1.82
1937	1,000,000	---	---	---	---

1/ Repairs

For the past five years the Department has been experimenting on a small pond of approximately one acre located near Fort Dodge in Webster County.

The source of water supply for this pool is a small tributary of the Des Moines River. The pool is so constructed that it can be filled and completely drained.

Some aquatic vegetation, including Elodea, Ceratophyllum and a small amount of Potamogeton, was planted to afford shelter and stimulate the oxygen supply. The average hydrogen-ion concentration is from 7.4 to 7.8, and the dissolved oxygen varies from 7 p.p.m. in the spring to 3 or 5 p.p.m. during the summer months. Food organisms consist primarily of Daphnia, Rotifers, Diatoms, Nematode worms, midge and damsel fly larvae. Forage minnows are usually introduced just in advance of their spawning season.

This pool has been stocked with varying numbers of fry to ascertain its maximum

carrying capacity. The following table shows the results. It will be observed that the cost has been very low on this unit. The reason for this is that it is only necessary to deliver the fry from the hatchery and to remove them in the fall. This requires only two or three days under normal conditions.

DOLLIVER POOL

Year	Stocked	Removed	Cost	Each (Cents)	Percent Survival
1932	70,000	6,200	$38.08	.6149	8.87
1933	100,000	7,100	25.25	.3558	7.1
1934	50,000	10.125	15.39	.154	20.23
1935	70,000	7,035	5.75	.0818	10.05
1936	200,000	5,100	15.30	.3	2.55

This season (1937) the Department is using three new units for the production of pike fingerlings in addition to the units previously used.

One of the new units, a 20-acre pond, is located at Clear Lake, in Cerro Gordo County. It has been formerly used as a large-mouthed bass pond with good results. Aquatic vegetation and food organisms have been well established, and the pond has been especially prepared for the production of pike this season. Fathead and blunt-nosed minnows have been added and the pond has been fertilized to produce an abundance of crustaceans. The water supply is obtained by gravity flow from a creek, and a pumping system from a reserve supply in the event the gravity flow is inadequate. The total cost of operating this pond is approximately $530.00 per year.

The pond has been stocked with 1,000,000 fry, and, at this writing, they are making splendid progress.

Another pond of approximately 25 acres has been acquired near Lanesboro, in Carroll County. This pond is fed entirely by three large artesian wells. It has a maximum depth of about five feet. It, too, has been especially prepared and stocked with 1,000,000 pike fry. Since there are no pumping charges involved, the cost of operating this pond is only $250.00 per year. This pond, as well as the one in Cerro Gordo County, can be drained completely.

The third new unit used for pike this season is a 10-acre pond located near Vinton, in Benton County. This pond was constructed on the Cedar River and is filled by overflow waters in the spring. It, too, can be drained during removal operations.

SUMMARY

We have found that under favorable conditions pike perch can be reared to fingerling size in comparatively large numbers.

We recommend the fingerlings be removed from the rearing ponds at the end of the rapid growing season (September and October) to eliminate possible losses caused by asphyxiation, cannibalism, etc.

We have found that the most successful pond units are those which have an adequate supply of fresh water and can be entirely drained. These ponds are not only more economical to operate, but are more effective since all of the fishes can be removed annually. In the larger units which cannot be drained, such as Diamond Lake and Welch Lake it is impossible to remove all of the fingerlings in the fall and consequently the pike which remain in the ponds prey upon the next years' fish.

The effectiveness of stocking fingerling pike perch in our lakes and streams is apparent, and populations are being built up, particularly in some of the streams where fry plantings have failed to produce results over a long period of time.

SUGGESTIONS ON STREAM IMPROVEMENT

By Osgood R. Smith, Ph.D.
Assistant Aquatic Biologist
U. S. Bureau of Fisheries

ALTHOUGH STREAM improvement is a relatively new procedure, it has been developed enough to prove that some streams can definitely be made better. Streams with long poolless stretches will often support more trout if pools are made, since trout will not stay long in shallow rapid water. Others may be made more suitable if the temperature can be lowered by narrowing a channel, or by planting shade trees. Snags and shelters fastened in a pool will make it more attractive to trout and will help to protect them from their friendly enemy, the angler. Perhaps some of the most spectacular improvements have been made in wide shallow streams with shifting sand bottoms. Such streams have been improved with devices which form pools, protect the banks from rapid erosion, or force the current to wash a narrow channel through the sand to expose firm gravel for spawning and food production.

Much good work has been done and there is plenty more to do. There has, however, been a great deal of harmful and useless work done in this country. A great deal of it has been done by men who did not understod just what biological and physical conditions are necessary for a good trout stream. The following article is submitted in the hope that it will help prevent repetition of some of the poor stream improvement work and aid in improving streams which really can be made better.

Much of the trouble with past work has been that the success claimed for stream improvement in one part of the country has led to the belief that it is a cure-all. Any informed fisherman realizes that the natural physical conditions in most streams are fairly good. Most of them had plenty of fish in them before intensive fishing or pollution ruined the fishing. But many people seem to forget this. They are struck merely by the lack of fish and then jump to the conclusion that the stream should be remodeled.

An example of overdone bank protection. Willows planted here would have produced the desired result at a fraction of the cost, and would not have given the artificial appearance.

To make matters still worse, just at the time stream improvement became popular, cheap labor in the form of the various relief agencies became available. The desire to make work found a ready outlet in a general desire to do anything possible to the streams, and then inexperienced men were pressed into service to do the actual construction without first having an impartial expert pass upon the advisability of the work. The sad truth is that many streams have been completely remodeled into artificial waterways, not because they needed it, but because they were near some CCC camp and happened to be on public land. In saying this, no blame is intended for the men who did the work. It has been the logical but unfortunate result of the rapid growth of a new idea.

Yet there is a real need for improvement on some streams, so let us stop and take stock of the situation before so much foolish work is done that public sentiment swings the other way and will not allow any work to be done at all.

To begin with, one should have a clear conception of the mechanics of stream erosion and sedimentation, and experience enough to understand what various eddies and current changes will do. For instance, one should always keep in mind the fact that most natural pools are caused by the digging action of the stream at a place where the current has been speeded up by snags, boulders, ledges of rock, or other obstructions. A large part of this digging occurs during high water when the current is strong enough to carry sand, gravel, or even boulders up out of the pool. Late in summer or during low water, the same pool may be so quiet that silt and debris will begin to collect in the bottom, but this will be quickly washed out with the next high water.

However, in a pond or any body of water which is permanently quiet, silt and debris settles to the bottom and eventually fills the entire basin, just as it has in many little New England mill ponds. Therefore any natural pool stays at a certain depth only because of the equilibrium between the eroding and the depositing actions of the stream at that point.

It follows from the above that any pool created above a dam will be short lived, while the pool which forms below it will last as long as the dam. This is a fact well understood by engineers and geologists but is often overlooked by the stream improvement workers. About the only exceptions to this rule would be very rare cases where bed rock or other firm banks confine a stream so much that it may be dammed up without creating a pool still enough for the deposition of silt. For the same reason, it is equally useless in most cases to make a natural pool deeper by backing water up over it. It is important to remember that a pool can be made permanent only with some device which will force the current to dig it and also to keep it cleaned out.

One of the most important things for the stream improvement worker to remember is that he must not do anything which will diminish the fish food supply of the stream. If the food supply is low the fish will grow slowly, reach sexual maturity slowly, and hence the supply of catchable fish will not be replenished rapidly enough to produce good fishing. Therefore, some information on the biology of trout streams is essential if mistakes are to be avoided. Over half of the food supply for trout has been shown to come from insects and other animals living in the stream itself. There are many kinds of animals living in the water and each must have proper conditions in order to survive. In slow muddy streams or lakes, for instance, some of the animals burrow in the mud, others crawl on the bottom, and others live on the plants. In rapid streams most of the food organisms live in the riffles rather than in the pools because the rocks or water plants offer a secure footing where the animals can stay in the rapid current, which both brings them food and washes silt away. If fine silt were allowed to settle as it does in deep pools during low water, the small insects would be smothered. If this did not happen, or even if mud dwelling species moved in, they would certainly be swept away along with the silt, during the next

flood. So we can see that the bottom of a pool must be a very precarious place for an aquatic insect to live.

Anyone can see for himself where these insects live. Next time you are out fishing pick up a stone from a riffle and count the number of mayflies, caddice flies, and other insects you find running around on the under side. Then take a stone from the bottom of a pool or even a shovel full of silt and note the relative scarcity of insects. Also note the feeding trout. They do not feed on the bottom of the pool but wait at the edge of the swift water for insects which may float down to them.

A natural log dam such as this one in Pennsylvania makes an excellent pool, and should be a model for the stream improvement worker.

Certainly then we must not do anything to a stream which will spoil too much of the riffle area. Just how much riffle area a given stream needs would be hard to say, but it probably should be at least a third the area of the pools. Surber (1936) found these proportions in a carefully measured trout stream near Leesburg, Va., and good trout streams in the northeastern states and in the Sierras of California seem to follow these general proportions. Johnson (1937) proposed a proportion of half pools and half riffles, thus allowing a trifle more area for food organisms. This

would probably be a safer figure to use in stream improvement work, especially in streams which are poor in food. The exceptions to the 50-50 rule would include relatively deep slow streams in which trailing water plants or snags offer dwelling places for insect life, even though no true riffles may be present.

There are many cases of streams being almost ruined by too many dams. Good streams have been transformed into a series of wide shallow pools which made the water so warm that the trout were replaced by warm-water species. Even if the water does not warm up, too many dams will unquestionably reduce the food supply. The successful fishing produced in some intensively improved club streams, or state "show streams" such as Pennsylvania's Fisherman's Paradise near State College, is not caused by the large number of dams usually installed. It is more the result of heavy stocking with large fish, coupled with rapid removal, and sometimes artificial feeding. As a result, there is no problem of growth to consider. This type of fish management is very good in its place, but it is neither possible nor desirable in most public trout waters. These should be as nearly natural and self-supporting as possible. So before starting to make a lot of pools in a given stream, let's make sure they are needed.

It would be safe to say that the pools are good in most streams, especially those in hilly or mountainous regions. Large boulders, ledges of rock, or the roots and snags in a well wooded region almost always make ideal pools. Even if there are no large pools, boulders will usually form good eddies where trout will lie. But streams may be found with long shallow "walking stretches," without either eddies or pools. Such a stream may be very rich in food, but there will be very few trout there to use it because trout will not stay long in shallow rapid water. Much better fishing can be produced if it is broken up into about half pools and half riffles, so that the trout will be scattered into more pools and there will be more tempting spots in which to cast a fly.

Such poolless streams are usually found in open country, where lumbering has removed the source of snags, and in regions where there are no large rocks and boulders to make pools and eddies. Where such a condition is found, pools should be made, or rather the stream should be made to dig them. There are many devices which will do this, which are fairly cheap and have proven to be stable.

In the smaller streams of 10 feet and under in width very good pools can be made with a single log across the stream. If large stones are available they should be placed on the upstream side, and the spaces filled in with gravel to prevent undermining. If large rocks are not available, undermining may be prevented by nailing fine-meshed heavy wire fencing or brush on the upstream side of the log and piling stones on this. Hazzard (1937) found that board facing on the upstream side of a log dam worked best in Michigan.

Then if a spillway is cut in the center large enough to carry all the stream during low water an excellent pool will form below. The fall need not be more than 6 or 8 inches in order to dig a good pool. Various dams will serve the same purpose

but most of them are more conspicuous and more expensive. A greater drop will sometimes dig a slightly deeper hole, but there is no need of it. Higher dams are not recommended because they are expensive, they can never look like a natural log dam, and they may do damage either by backing up the water over desirable riffles or by causing the stream to change its course.

An effective and cheap single log dam, in Utah. (Photo by P. R. Needham)

For larger streams, the famous Hewitt dam seems to be very satisfactory, and about as inconspicuous and cheap as any.

Good, natural-looking dams may sometimes be made with large rocks. Large angular rocks may be wedged together to form an arch with the keystone upstream, or very wide flat ones may serve, but in any case there should be a good spillway. Round boulders ordinarily do not make effective or permanent dams. Unless ideal stones are available the best place for a rock dam would be seven or eight feet below a log dam. In this location it will help to maintain the level in the eroding pool below the log. The same principle may sometimes be applied to natural pools if it is done

with care and the water is not backed up enough to cause deposition of silt.

Good pools may also be made with various current deflectors, instead of dams. These have the advantage of speeding up the current and forcing it to dig without creating any area of still water which will fill up with silt. This was found to be true in Michigan, where shifting sand fills all quiet pools. In fact Hazzard (1937) says that dams should not be installed in soft bottom streams, and log deflectors only should be used. Good pools may also be made in small streams by installing a single log in such a way that the current will go under it and dig out a hole. Such a log will thus not only dig a hole, but will also form shelter for the trout. In fact, one advantage of the single log dam is that if the current should work under it, it will still be a valuable improvement device. Deflectors are especially valuable in straight shallow streams which are over 10 feet wide and hence difficult to control with single log dams.

In small streams suitable deflectors for narrowing the channel can be made with a single log imbedded firmly in the bank and pointing downstream at an angle of 45 degrees. If the banks are not very firm it may be well to put braces into them on the downstream side of the log and fill the space between the brace and the log with rocks. If large rocks are available a row of them will also make a good deflector. In larger streams over 20 feet in width, good deflectors can be made with logs notched and spiked together in a ladder-like structure and then filled with rocks. As with the single log, one end should be firmly embedded in the bank. The cross pieces should be on the underside, and set down into trenches in the stream bed. Then when this is filled with rocks the cross pieces are buried and the whole structure is not more than one log in height. If good large rocks are not available, fine-meshed heavy wire fencing should be stapled over the logs and the rocks piled on this. By keeping the devices low they not only are less conspicuous but they are less likely to be washed out because high flood waters and trash will flow over the top.

Deflectors designed to narrow the channel can be placed opposite each other, making a double deflector, to keep the stream from eroding its bank. However, if the stream is small and the banks firm it may be just as well to force all the current against one bank. In this way the stream is not only made narrower, but a good pool will eventually form against the bank, where rocks or tree roots will make good shelter. Very often the current can be directed against some large boulder, or ledge of rock, which will prevent excessive bank erosion even in large streams. This is one of the many cases where good judgment must be used. Tarzwell (1936) found that simple, straight deflectors, or "wing deflectors" were more satisfactory than more complicated ones with current directors, since the latter sometimes formed barren, silty areas. They also are cheaper.

The various devices which are sometimes installed in the center of streams have generally been unsatisfactory both in Michigan and elsewhere.

Temperature may be the factor which determines whether or not trout will stay in a stream, so this should be considered before undertaking any work. Summer

temperatures of about 55°-70° are good for brook trout, and brown and rainbow trout will stand temperatures up to about 80°, if oxygen conditions are good. Oxygen, however, is almost always plentiful in running water.

If a stream gets warmer than 70°-80° F., it can usually be cooled slightly by shading and by installing various deflectors to narrow the channel and thus give less surface water to be warmed by the sun. When this is done, however, care must be taken to build deflectors which will speed up the current in one place without pro-

Snags fastened over a natural pool in Rhode Island. Such snags make good natural appearing trout hides for streams which do not flood badly.

ducing a wide still area in another. Elementary as this may seem, just that mistake has been made. One such device seen by the author in Connecticut had a large sign nearby stating that it was installed by the CCC to cool the stream, but a wide still area formed above had probably counteracted any cooling effect it might have had. Incidentally, this was an enormous rock and log cribbing structure costing over a thousand dollars.

If a warm trout stream flows through open land, trees or brush should be planted along its banks for shade. In the long run this will probably be more effective than all the deflectors which could be installed.

Tree planting brings us to the matter of bank protection, which has often been made a large part of stream improvement programs, and has produced some of the most costly and unsightly work of all. Before we spend many more thousands of dollars on it we should stop a bit to consider its worth and the various means of accomplishing it.

A rock dam in the Pisgah National Forest, North Carolina. Note the natural appearance with no trace of artificialty.
(U. S. Forest Service Photo by Clint Davis)

In the first place, small eroding banks seldom harm fishing. Most of them actively eroded only during high water and the silt carried at such infrequent intervals does not materially harm either fish or aquatic insects. Practically every pool is caused by erosion so we should not worry too much if the effects of erosion also appear on the banks once in a while.

Rapidly eroding banks can, however, do a great deal of damage. Such banks may often be seen where a stream flows through open fields. In such places a stream frequently will cut into first one bank and then the other, eventually producing a wide shallow stream bed, without deep holes, poor in food, and subject to high temperatures. Such banks should certainly be protected. One method would be to use log cribbing, but this is very expensive, artificial looking, and not permanent. Its principal advantage lies in the fact that it will be effective immediately. A far better method for most streams would be to plant willows along the banks. Poles or large stakes cut from a large species of willow such as Salix alba and set in diches in the bank or pushed into mud will sprout roots within a year. If a bank is wearing away very rapidly the willow stakes should be set far enough back from the stream so that they will not be carried away before the root system has a chance to develop. In two or three years the roots should hold the banks against almost any flood, and it will not be long before a little shade is produced and the roots will work out into the stream bed to form beautiful pools.

Willow planting is an effective and cheap method of restoring the conditions existing before man cut off all the woods and let the streams run wild. There are many willow bordered pasture streams which show what willows will do, and an excellent example of their use for bank protection may be seen on Cascadilla Creek at the Cornell University Hatchery, in Ithaca, New York. Willows and other trees, when once well established along a small stream, will produce and maintain many of the improvements for which the various complicated devices are designed. They will do it at a fraction of the cost, and they will not turn the stream into an artificial-looking canal. Simple mechanical devices may still be advisable, especially in very wide shallow streams and very straight poolless ones, but even then there should be trees to keep the stream under control and supply snags after the other devices have rotted or washed away.

Greeley (1935), Aitkin (1935), and others have advocated tree planting, but judging from most of the improvement work one sees, the idea has not spread very far.

Occasionally one will find a high bank which is constantly dropping such a load of fine silt into a stream that the rocks below become coated. This will tend to drive out aquatic insects, so it is a case of direct damage from silt. In most cases willows will also protect this type of bank, but a deflector or two may also be advisable to turn the current away.

If the temperature, pools, and food conditions of a stream are suitable, and yet trout are scarce, the reason is usually over fishing. The cure for a case such as this is largely one of proper management and adjustment between supply and demand. About all the stream improvement technician can do is to protect the fish a little by making angling more difficult. Stumps, old logs, or the tops of trees fastened in or over pools give excellent protection. A certain amount of originality must be exercised in this type of stream improvement to give the desired effect without an artificial appearance. Tree tops may sometimes be fastened over a pool by hooking one branch around a convenient tree or root. Another method which is effective for small

streams is to cut a notch in the butt of a tree top, securely spike on a cross-piece to form a T, and then bury this deeply in the bank. These tree tops can usually best be fastened at bends, where the brush end will swing downstream and against a bank, just as one often finds an uprooted tree lodged naturally. To add variety a tree may sometimes be fastened with the top upstream, catching the branches on convenient

Shallow riffle broken by a series of low rock dams.

trees. Stout wire or cable may also be used to fasten snags in some small streams, but these often will twist and break away during floods. The above-mentioned snags are not recommended for rapid streams over 15 or 20 feet wide, very steep mountain streams, or streams which are badly scoured by ice jams.

It would be a great benefit to most trout streams if we could do something to increase the food supply. According to Tarzwell's work in Michigan (1936), it is possible to do this in some streams with silty or sandy bottoms, by speeding up

the current so that it will wash away the silt and sand, expose film gravel, and form a short riffle. The food producing advantages of riffles have already been discussed. In muddy streams weeds will sometimes grow on the sheltered side of deflectors, and this also will increase the food. But in most trout streams gravel or rubble riffles are already abundant, and there is no proven method of increasing the food supply.

Trout spawning conditions should also be improved wherever necessary and possible. The situation here is almost exactly like that of improving food conditions. Trout like to spawn on gravel bottoms in the relatively swift smooth water at the lower ends of pools. Small gravel spring runs are also used, even where there is not much current. Just as with the aquatic insects, silt and sand will smother the eggs. Therefore, in sand or silt bottomed streams, spawning grounds can be made if the current can be forced to expose good gravel. This will often happen at the eroded pool off the end of a deflector, below a small dam, or just down stream from an under-current log.

A very different type of stream improvement has been successfully practiced in arid regions of the west (Needham, 1936). This has been the construction of check dams, which are designed to store the water during the rapid spring run-off from the mountains, and let it run out gradually during the dry season. In this way many miles of trout streams have been improved by maintenance of permanent year-round flows. It is exactly the same principle as the storage of water for power and irrigation, except that the dams are small, they are located in the headwaters, and the flow is controlled automatically, with an outlet made just the right size so that the water stored will run off gradually all summer.

Summary and Conclusion

Most natural pools are caused by erosion, not damming up of water, and pool-making devices should be designed to function in the same way.

The bulk of the aquatic food of trout comes from the riffles. About one-half of a stream should be left as riffle area.

Dams should be low and simple. Underpass logs and simple straight deflectors are generally most satisfactory. They should be low for strength and appearance. Simple deflectors will both narrow channels and dig pools. Devices fastened in center of stream are not recommended.

Warm streams can be cooled with shade and by narrowing channel.

Bank protection should be done with willow or other trees wherever possible, avoiding log cribbing, which is unsightly, expensive and not permanent.

Snags to protect fish are desirable on small, heavily fished streams. Tree tops, and snags, can be hooked on trees or embedded in banks. Wire is not recommended for fastening.

Both food and spawning areas can be increased in silt or sand bottomed streams, by forcing the current to expose clean gravel.

In arid regions a permanent flow of water can sometimes be maintained with check dams.

And last, but not least, one should not try to improve too much on nature. Most trout streams are already very good, especially in hilly and wooded regions. Stream improvement devices will not improve the fishing unless the stream has some characteristic which is detrimental to trout, yet which is also subject to artificial improvement. Such characteristics would be a deficiency in pools, extensive wide shallow areas, high temperatures, rapidly eroding banks in open country, a deficiency of spawning and food-producing areas due to sand or silt, or possibly a lack of snags to give protection. If these conditions are not found, the stream should not be improved. Better fishing can only be produced by better management.

Bibliography

Aitkin, W. W.
1935 Iowa stream improvement work. Trans. Amer. Fish. Soc., Vol. 35, pp. 322-324, figs. 1-6

Davis, H. S.
1934 The purpose an value of stream improvement. Trans. Amer. Fish. Soc., Vol. 64, pp. 63-68

Davis, H. S., Hazzard, A. S., et al
1935 Methods for the improvement of streams. U. S. Bur. of Fish. Memorandum 1-133, Jan. 1935, Ill.

Greeley, John R.
1935 Progress of stream improvement in New York State. Trans. Amer. Fish. Soc., vol. 65, pp. 316-322

Hazzard, Albert S.
1937 Results of stream and lake improvement in Michigan. Trans. 2nd N. Amer. Wildlife Conference, 1937, pp. 620-624

Hewitt, Edward R.
1931 Better trout streams. Chas. Scribner's Sons. New York, 1931

Hubbs, Greeley, and Tarzwell
1932 Methods for the improvement of Michigan trout streams. Bull. Inst. for Fisheries Research, U. of Mich. No. 1, pp. 1-54, figs. 1-13

Hubbs, Tarzwell, and Eschmeyer
1933 C.C.C. stream improvement work in Michigan
Trans. Amer. Fish. Soc., Vol. 63, pp. 404-410
figs. 1-5

Johnson, Fred W.
1937 Report on stream improvement structures at
Mineral King - Sequoa National Forest.
Associated Sportsman (Calif.) Vol. III, No. 5,
p. 5.

Needham, Paul R.
1936 Stream improvement in arid regions. Proc.
N. Amer. Wildlife Conference, Feb. 1936, pp. 453-460

Surber, Eugene W.
1936 Rainbow trout and bottom fauna production
in one mile of stream. Trans. Amer. Fish Soc.,
Vol. 66, pp. 193-203

Tarzwell, Clarence M.
1931 Trout stream improvement in Michigan. Trans.
Amer. Fish. Soc., Vol. 61, pp. 48-51

1936 Experimental evidence on the value of trout
stream improvement in Michigan. Trans. Amer. Fish.
Soc., Vol. 66, pp. 177-188

NOTES ON WARM-WATER FISH CULTURE

By C. F. Culler, District Supervisor,
U. S. Bureau of Fisheries, La Crosse, Wisconsin

ALMOST EVERY phase of fish culture is more or less controversial. This is due to the conditions that exist at the different hatcheries, both State and Federal. Many articles are written but they are usually the results of experiments at one particular place; therefore, they may not be applicable to the fish cultural stations in the United States as a whole. It is true that the fundamentals of fish culture are the same, but it is also true that each fish culturist must work out his own salvation at the particular point at which he is stationed.

In warm-water fish culture, however, no one will dispute the fact that with

sufficient pond area, large numbers of fish can be produced if the food supply is present. We all know the type of food we should have, but the question revolves around this point -- how are we going to produce it in quantities sufficient to rear the large numbers of fish required for the increased stocking that is necessary for the upkeep of angling?

Several years ago the writer conceived the idea that something should be done in regard to the food situation. He believed that if a set-up could be arranged with the biological, zoological and chemical departments of one or two of our universities graduate students could ascertain by the use of fertilizers in pure water, what introduction of chemicals would be necessary to produce the maximum amount of daphnia per cubic foot of water. With this as a basis, a traveling laboratory could be set up, and under scientific supervision could make periodic visits to the hatcheries. There they would make chemical anayses of the water and after a comparison, advise the production man in charge just what chemicals should be introduced to produce the maximum amount of animal life absolutely necessary for the production of fish. This traveling laboratory should be such that the analyses could be made in a comparatively short time. It is believed that if some such information could be had, the average production of black bass per acre, which now is approximately 6,500, could be increased to double that number. The question of chemical changes in the water supply has been advanced, but it is believed that this would not enter into the picture to a large extent, because the concentration of the chemical constituents of the water will not be severely modified until after a production period of crustaceous life is ended by high temperatures.

During the past season an unusual condition was observed at the Northville, Michigan, station where the ponds had been drawn and the fingerling bass taken out. Later, the pond was filled and fertilized with marsh hay and the bass returned to the pond. At the time of the observation, the pond contained unbelievable numbers of Daphnia magna. The temperature of the water in the pond ranged from 84 surface to 79 on the bottom in 2½ feet of water. This would seem to indicate an ideal chemical set-up in the water supply. It is believed that the production at the several stations has been limited because the chemical constituents of the water vary and when certain chemicals are introduced in a ratio dictated by chemical analyses elsewhere a deficiency occurs and the production of food is curtailed.

At this point there is the question of stocking of adults in the brood ponds or in rearing ponds, as alternative to the transfer of advanced fry from the brood ponds to the rearing ponds. It has been our experience that by stocking with 15,000 advanced fry per acre, the results obtained at the average station are as satisfactory as where 25,000 per acre are used. Similar conclusions were reached in stocking with adults. Experience has shown that it is highly probable that too many adults per acre have been used in the past because little has been known of the egg production of the several members of the warm-water fish group. For example, it has been the custom to stock the brood ponds with thirty pairs per acre where the fry were to be taken from the ponds, but little thought was given as to the number of fry a pair of fish would produce. At La Crosse four pairs per acre are used in stocking the

experimental pond. For the year of maximum production when the output was 27,225 No. 3 fingerlings per acre, but two pairs per acre were stocked. At Genoa, the bass are stocked at the rate of four pairs per acre. During the season of 1937 this pond produced 737,415 fingerling bass. This would seem to indicate that four or five pairs per acre would be the proper number of adult bass to stock per acre in large pounds. An experiment is being carried on and while we have the results of only two years, the evidence is apparently conclusive that the production of eggs is far more than has been generally believed.

The first year of this experiment an actual count was made of the eggs contained in the ovaries of the female just before the fish were placed in ponds in advance of the spawning season. The second year, in cooperation with Dr. Will Scott (now deceased), of the University of Indiana, the egg count was made by scientific measurement and in a report received from him this past fall, he advised that the ovaries taken from a 2 lb. 12 oz. largemouth black bass showed a count of approximately 79,000 eggs and a smallmouth of the same size, 13,862 eggs. However, the ovaries of this fish contained seven tapeworms. The year previous by actual count, at the Northville, Michigan, station, a largemouth black bass weighing 1-3/4 lbs. produced 31,008 eggs, while the count of a 2½ lb. largemouth at the Rochester, Indiana station (this fish was 8 years old) shows 109,314 eggs. A smallmouth bass at the Manchester, Iowa, station, weighing 17 oz. showed a count of 20,825, while at the Fairport Iowa, station a largemouth weighing 1 lb., 10½ oz. showed a count of 22,300 and a smallmouth weighing 1 lb., 7½ oz. only showed a count of 5,040. At La Crosse a largemouth weighing 1 lb. 3 oz. produced 30,481. It might be said that the Northville count was obtained from a fish five years old, from the La Crosse station 4 years, from Manchester 3 years, and from the Fairport station, 4 years. These were all largemouth bass.

Then the question arises as to whether or not all of these eggs are spawned. Over a period of years, the writer has examined over 200 female fish in July and August and has never found where any eggs had been retained although he did find eggs for the next season.

In connection with the egg production of the other members of the warm-water group, it was found at the Northville station that a blue-gill sunfish weighing 6½ oz., two years of age produced 32,950 eggs. At La Crosse a sunfish weighing 8 oz., two years of age produced 27,320 eggs. At Fairport a two-year old sunfish, weighing 4 oz., produced 12,000 eggs. At Rochester a black crappie weighing one pound, 7 years of age produced 158,696 eggs. At La Crosse where the adult crappie weighed only 8 oz., three years of age it produced 16,954. The counts of sunfish and crappie with one exception were actual counts. The one at the Rochester station was made by Mr. E. H. Steen, who is in charge of the Wild Life Management Program at Purdue University. The scale readings were made by Drs. Juday, Van Oosten, and Hazzard.

There is another angle, are we using the proper sex ratio in our stocking? Some have advocated the use of two females to one male. It is a well established fact that the female bass does not spawn all her eggs at one time. Usually they are deposited in two or three intervals. Then the question naturally arises as to the ability of the male fish to fertilize the eggs from two females. While it is a well established fact also that this has been done with members of the salmonidae, nothing is known whether this is true of the male members of the warm-water fishes. Therefore, with the egg production so much larger than is generally believed, and the low production that has been apparent when one male is used to two females or even when the sexes are equal, there is the opportunity for an argument as to whether or not it would be advisable to use two males to one female, or possibly three. So that something definite may be known in this connection, it is proposed to carry on experiments at the Lake Mills Station in several small ponds that have recently been constructed, stocking these ponds with the following ratio: ne male and two females; one male and one female; two males and one female; and three males and one female. After this experiment has been carried on for a couple of years, we should have something definite on which to base our stocking plans in the future.

In the stocking of rearing ponds with advanced fry it is believed that the noticeable difference in the results obtained is due, to a great extent, to the methods used in collecting and transporting the fry from the brood pond to the rearing pond. It is our belief that in many of these instances large numbers of fry die from Bacillus columnaris contracted through handling when water temperatures are high.

It is believed by many that black bass cannot be reared successfully to No. 3 fingerlings except when they are artificially fed or are fed by the introduction of forage fish. In experiments that have been carried on at this point our greatest production per acre was made when the fish had nothing to eat except daphnia and larval insect life. Many have advocated the use of golden shiners as a forage fish. It is assumed that this is done because they are prolific, but experience has taught us that the shiners should be reared in a smaller pond and then transported to the rearing ponds rather than introduced as adults into the brood bass or rearing ponds. It is an established fact that golden shiners have severe cannibalistic tendencies and when other forms are not present they will eat small bass fry or the young of any of the warm-water fishes.

Strange as this may seem, we have found the same thing true of goldfish. We have observed adult goldfish swimming in a school of largemouth bass fry and gulping them down in large numbers. We have also observed that when the adult goldfish were taken from a pond where they had been used as forage fish, and were placed in a trough in the hatchery, they disgorged bass, ranging from 1" to 1¼" in length. It is our belief that the proper forage fish to be used in bass culture are the blackhead and blunt-nosed minnows, although the spot-tailed could just as well be used where it is available.

The proper types of plant life to be used in brood and rearing ponds has been a moot question for a long time. However, it is believed that plants of the semi-marginal type which extend above the water should receive more consideration than they have in the past. It has been our experience that plants like the reed canary grass and the so-called sword grass which extends above the surface when it is planted in two to two and one-half feet of water have certain advantages that are not offered by the purely aquatic species. The plants extending above the water not only furnish protection to the small fish, but it seems that more insect life is present and that they also give greater shade than the purely aquatic plants.

In the rearing ponds where there is a heavy growth of any of the forms of the purely aquatic plants and where the ponds are left until late fall to be drawn, the plants start to decay from the ground up and there is a certain amount of sludge built up from this decomposed vegetation each year. This, in the course of a few years, will reach a depth of six or seven inches and it has been the experience with all production ponds that after the first couple of years the number of fish reared in these ponds decreases. To overcome this, the ponds are drawn as early in the season as conditions warrant and allowed to lie open to the sun's rays until they are filled the following spring. When it can be done, the bottoms are harrowed and then planted with any type of grass seed that is available. However, it is preferred that reed canary grass be used. The harrowing of the bottoms has been followed in actual practice at the Fairport station for several years and an increase in the output was immediately noticed. It is believed that if the ponds could be allowed to stand idle for one year and grow up in clover or reed canary grass, an increase in output would result. It is further believed that an analysis of soil samples taken from the bottoms of the ponds for the purpose of determining the proper plants to introduce would contribute to an increase in the production of warm-water fishes. This is in line with an article recently published in THE PROGRESSIVE FISH CULTURIST, entitled, "Fertilization of Fish Ponds in Czechoslovakia," by Mr. Edward B. Lawson, Commercial Attache, U. S. Bureau of Foreign and Domestic Commerce.

It is necessary at the present time for us to call on other governmental or state agencies for certain information and it is believed that if regional biologists who also have a knowledge of chemistry whereby soil and water analyses could be made would cooperate, fish culture would immediately show a great advancement.

As said in the beginning, fish culture is usually a controversial subject and it is more than likely that we will be taken severely to task by fish culturists for certain assertions we have made in this article. Regardless of that fact, the instances mentioned above are the results of experience and technical observations and until it has been shown that we are wrong these observations will continue to be used as the basis of our fish cultural operations. As has been stated before, one of the great troubles in the writing of articles on fish culture is the fact that the examples cited are local and are not always applicable to other parts of the country where water and climatic conditions are entirely different. However, the fundamentals of fish culture are the same wherever you go. If proper care is taken

in the selection and feeding of brood stock1/ and in the transferring of the advanced fry, and if sufficient acreage is provided for the fingerling fish with proper fertilization of both the brood and rearing ponds, there is no question as to the ultimate successful results.

CORRECTION AND NOTICE OF A NEW PUBLICATION

PROFESSOR G. C. EMBODY requests the correction of a statement made on page 3 of our December 1937 issue, No. 34, with reference to availability of his "Outline for the Development of Stocking Policy." Except for a few copies that were sold by the Departmental stock room at twenty-five cents each, no charge has been made for Dr. Embody's outline; and, furthermore, the booklet is out of print and is no longer available.

For the present, therefore, students of fish stocking must rely upon any copies of this publication available in libraries, but during the spring the Bureau of Fisheries expects to publish a fishery circular "Instructions for conducting Stream and Lake Surveys," by H. S. Davis and the Aquicultural staff of the Bureau. This circular is based on Dr. Hazzard's mimeographed instructions for stream and lake survey work, issued by the Bureau in 1935, but is completely revised and considerably extended. The circular will contain a new stocking table similar to Embody's but modified by subsequent experience. While the date of publication cannot be stated in advance, THE PROGRESSIVE FISH CULTURIST will publish notice when it is available.

EDITOR

1/ Superintendent Dell Brown of the Bureau's Station at Mammoth Springs, Ark., advises he gets the best results from his brood stock by feeding minnows and crawfish for at least six weeks before the adults are placed in the brood ponds.

3407

COMMENTS FROM OUR READERS

FEEDING TROUT IN STREAMS AFTER PLANTING

Editor, Progressive Fish Culturist:

Some years back when some fish cultural work was being done on a small spring fed brook at the head of Big Averill Lake, Vermont, under the direct supervision of Mr. E. C. Tillotson, sometime during a dry period early in August when there was not enough water available to carry all the fingerling brook trout in the troughs I wrote Mr. Tillotson telling him to plant most of the trout in various small streams flowing into Big Averill Lake and into Forest Pond, also to place some of the fish in the stream below his troughs and to feed them. Feeding was done only in the stream below the troughs since he did not have time to go daily to the other streams.

Some six weeks later when I visited the nursery I found the fish in the stream below the nursery in splendid condition. They had grown, had taken on color, had learned to hide beneath rocks and overhanging banks, to dart out after food and apparently had learned all the tricks of wild trout. At that time they were from three to five inches long. I was so well pleased with them that I decided to stay over a day and visit the other streams in which trout had been planted but in which no feeding had been done. I spent nearly a whole day along these small streams and in only one of them did I find any fish above those normally found therein except in one rock bound pool in which a little spring water entered. Here was a school of from 50 to 100 thin, dark colored, sluggish, listless trout in length averaging about like those planted therein about six weeks previously. They had made no growth whatever but looked even smaller than when released. What became of them later I do not know.

Mr. Tillotson continued to feed the trout in the nursery brook until late in October when the work was discontinued for the year. The distance from the nursery troughs to Big Averill Lake was only about 150 yards. Where these trout spent the winter is not known but they were not in the brook the following spring when the nursery was reopened but early in July when the lake water became warm they crowded into the nursery brook up to the dam some forty yards above the troughs. Beyond that they could not go. At this time they ran anywhere from 5 to 8 inches long. Again early in August the flow of water dropped to less than 10 gallons per minute and most of the fish had to be planted. It was about this time Mr. Tillotson wrote me saying he was having a hell of a time salvaging brook trout stranded in pools between the dam and where the water fro the troughs re-entered the brook channel some seventy yards below the troughs.

Some time late in September following some rains that increased the flow of water I visited the nursery and when I asked Mr. Tillotson why he had not again planted trout in the nursery brook he used quite a lot of various cuss words in telling me he had had all the experience he wanted in trying to get slippery trout from under rocks and from beneath overhanging root-bound banks.

The work at this place was discontinued the following spring and the experiment has not since been repeated but the writer feels that there is something worth while in feeding trout for some time after planting them in open waters, particularly in waters not having an abundance of natural food.

J. P. Snyder, Supt.
U. S. Fishery Station,
Cape Vincent, New York.

THE WATER-DISSEMINATION METHOD FOR FEEDING FISH BY MEANS OF A WATER DISTRIBUTING PIPE LINE SYSTEM

Editor, Progressive Fish Culturist:

During the past summer, I had the good fortune to be employed at one of the many fish hatcheries operated by our State Division of Conservation. My job was to feed the fish in the breeding and rearing ponds.

The method used to feed the fish is a simple one and probably is similar to those in general use in other hatcheries. Carp and goldfish are ground into a fine "meal" and fed to the fish by someone casting it into the water from the banks of the pools. This task becomes increasingly more difficult as the filamentous algae reach the optimum of their vegetative growth and generally coincides with the period in which thefry begin to feed on the ground fish. It happens that during the early stages of their development the fry remain rather close to shore and seldom venture into the deep water. uring this early period of development the fry use the algae as a natural protection from the larger fish and other predatory animals.

Under present conditions only about 50% of the food cast into the ponds is eaten by the blue-gills. To off-set this loss of food several pairs of bullheads should be placed in each of the ponds. For the most part, these scanvenger fish will devour the food which settles to the bottom of the ponds. This, however, is not entirely satisfactory even in hatcheries which do employ the scavenger system. The bullheads eat much of the food which is still in motion whereas it should be consumed by the sporting fish. Naturally this runs up the cost of production of game fish. It is evident that a method of feeding whereby food can be distributed to the fish

without being lost on top of large aggregates of algae or consumed by scavenger fish had to be devised.

The present method, as employed at the hatchery where I worked, is rather costly. In the first place, the maintenance of such a hatchery is too high since it requires from two to three times as many men as should be necessary to operate it. Furthermore, the present method of feeding requires almost twice as much food as the fish will readily consume in a feeding period.

The remedy for this lies in the use of the water dissemination feeding system, a procedure which I was able to develop during the summer. After two and a half months of test feeding by this method, I was able to study some of the various angles of water dissemination feedings.

Description of the Feeding System: For economy's sake, the water-supply and water-dissemination feeding systems are the same. However, wherever a direct fresh-water supply to each pond is not used, this type of feeding system is practically out of the question. Thus, unless water is piped directly to each pond or block of ponds, this method cannot be used to great advantage.

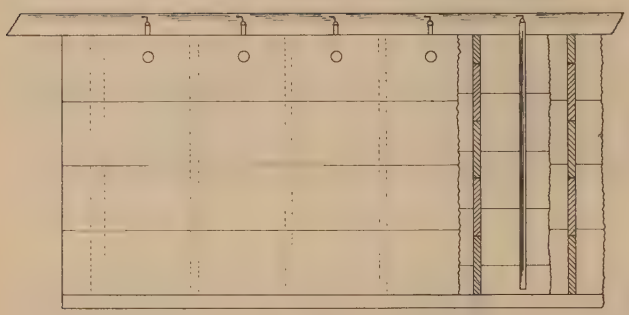
The system is simple in itself. The main water-supply flows into a deep concrete box from which the water is piped to the rearing ponds which may be laid out in "blocks" of four ponds to each block. A valve at the box controls the water supply to a rearing-pond block, while other valves control the water flow into each pond. A system of 1-1/2 inch to 2 inch pipes extends the entire distance around the pond and about two inches below the surface of the water. Holes 3/8-inch to 1/2-inch are drilled in the pipe at intervals of about 12 inches so that they face toward the center of the pond.

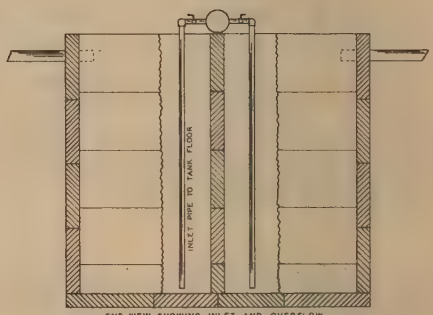
The ground fish or meal is first mixed with water and the large chunks of food are broken up to facilitate passage through the pipes. This "mix" is then dumped into the central feeding box. By regulating the valves, the food and water-supply may be regulated for any "block" or individual rearing pond. This will supply the fish with food which is in motion. If the food drops from a point above the surface of the water, it tends to settle to the bottom of the pond almost at once, thus affording forage for none but the scanvenger fish.

Some Results of Water-Dissemination Feeding: The ground food which is water-disseminated is provided for a much longer feeding period, thereby being more desirable. For example, ten pounds of feed was placed in the central distributing box and for more than a half hour the food continued to be distributed to the rearing ponds, while on another occasion this process continued for about 45 minutes. On the other hand, it was impossible to feed one pond, by the hand distribution or casting method, for more than seven minutes and still make the rouuds of all of the ponds.

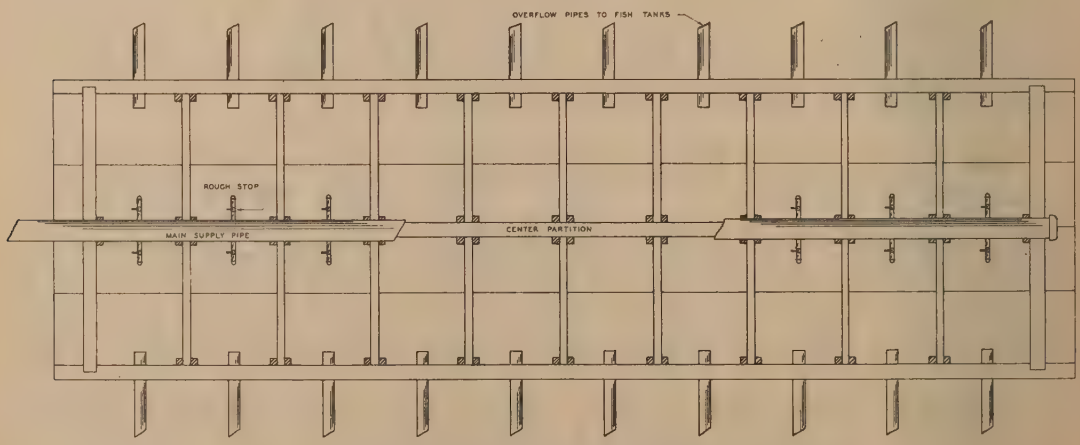
Naturally, feeding which covers a longer span of time is desirable since the ratio for food fed to food consumed more nearly approaches one. Likewise, this

DISTRIBUTION PIPE WITH OUTLET HOLES DRILLED ON UNDER SIDE
WATER INLET
FEEDER BOX
LAYOUT PLAN FOR INDIVIDUAL TYPE FEEDING BOX NEAR TANK
NO SCALE





END VIEW SHOWING INLET AND OVERFLOW PIPING



SCHEMATIC LAYOUT PLAN FOR CENTRALIZED FEEDING UNIT

12 INCHES

method of force-feeding gives all of the fish a better chance then does the present method which is merely periodic feedings.

Wherever operation costs are a large factor, the water-dissemination method may serve as the answer to the problem. At present, one man can feed but about 10 or 12 average sized ponds about six or seven times a day, but with the water-dissemination system, the same man can feed approximately ten times that number continuously for a span of from eight to ten hours if desired. In addition, it makes it possible for him to assist with other odd jobs about the hatchery without interrupting the feeding process for any length of time.

By using the water-dissemination method, food can be distributed all around the pond at the same time and in smaller portions. This establishes better feeding habits among the fish population. In the same instance, it permits all of the fish to have a more nearly equal opportunity to feed.

Individual problems of hatcheries and their solutions will vary, but for a new hatchery the rearing-pond block arrangement with a central feeding box should prove far better than almost any other plan. Here efficiency in the hatchery from the beginning will provide the greatest ultimate economy of operation.

Fred H. Glenny,
Akron, Ohio.

SUGGESTION FOR A FISH GRADER

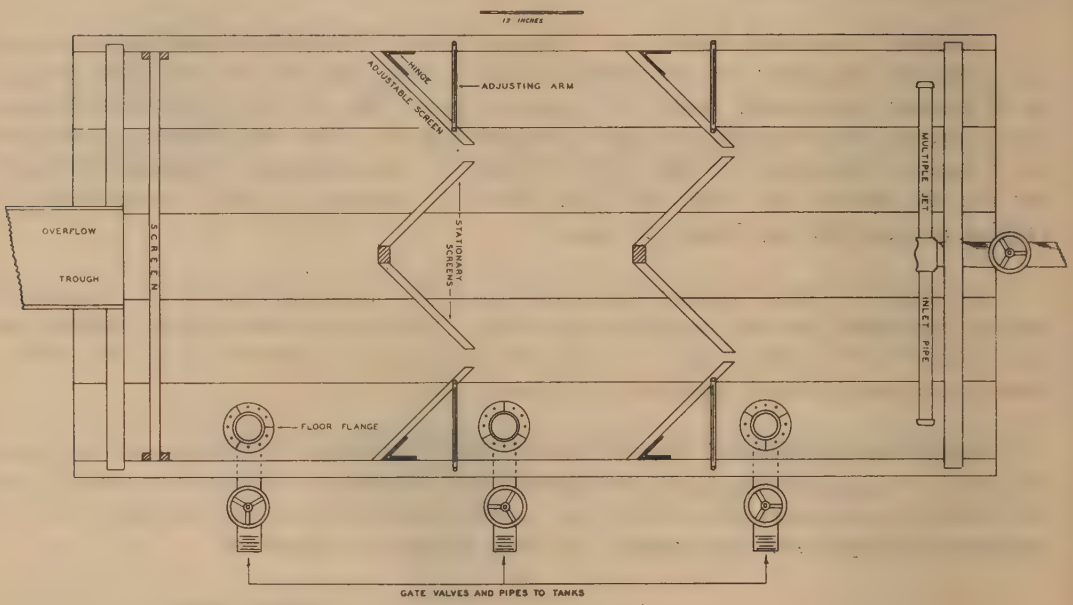
Editor, Progressive Fish Culturist:

I am enclosing herewith, a suggestion for a fish grader. Ever since I read the article by Paul R. Needham, in the October 1935 issue of the Progressive Fish Culturist, which describes a cheap, adjustable fish grader, I have been trying to conceive a faster, more efficient grader to accomplish this all important task.

I regret that I have only conceived it and have not had the time nor space to build and perfect such a grader before offering it to other fish culturists. However I sincerely believe that such a grader, after a little experimenting and perfecting, would prove a very valuable piece of equipment at any hatchery where large numbers of fish are raised and liberated each year.

The grader could be built to any size in order to meet local requirements or to speed up its efficiency. The openings in the traps could be made adjustable in order to grade real large fish, or to grade small fingerlings. To explain its operation we will say that a tub of fish, ranging from 2 to 6 inches, is dumped into section

SCHEMATIC LAYOUT PLAN FOR PORTABLE FISH GRADER



No. 1. With a large volume of water pouring in at the inlet the fish would have a natural tendency to swim towards the head of the tank. In so doing, the larger fish would be held back in Section No. 1, the next in size would be held back in Section No. 2, and only the smallest fish reaching Section No. 3. After they have all reached their respective places, the flow of water could be cut down and the valves at the side of the grader opened, thereby draining each section into a separate tank. While the grader is being filled another one or two tubs of fish, depending on the size of the grader, could be seined up and the operation repeated until the pond from whence they came is emptied.

The pond could then be thoroughly cleaned and only one size group, with the largest number in it be replaced in the pond. The remaining size groups in the tanks would be held there while another pond is being graded and until enough of them had been accumulated to fill a pond by themselves.

Such a grader would have several distinct advantages:

1. It would grade thousands where the old hand method only grades hundreds.

2. It would be a great aid at liberating time by ensuring a more accurate count.

A. It would give 3 or 4 size groups that would make liberating easier by reserving the larger groups for stocking the more heavily fished waters and the smaller ones for stocking remote areas.

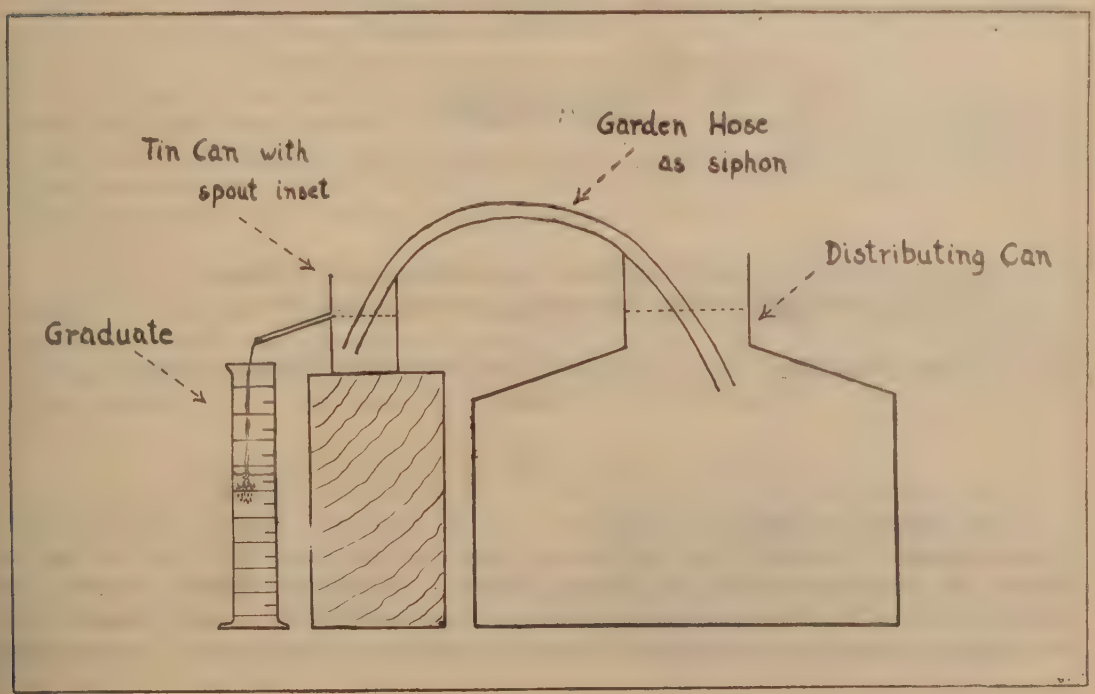
3. It could be made as stationary piece of equipment, located at near as possible to the center of all ponds, and the tanks at the side of the grader could always be used at other times, for salting or giving the the fish any treatment that might be necessary.

K. E. Morton, Asst. Foreman
Hood River Hatchery,
Hood River, Oregon.

A SIMPLE METHOD OF MEASURING VOLUME OF FISH

Editor, Progressive Fish Culturist:

In one of our experiments to determine the comparative rates of growth in two lots of fish it was found desirable to measure the total volume of fish in each lot



rather than the lengths and weights of individual fish in representative samples. Since it was impracticable to do this by the simple displacement method using a graduated cylinder, a modification of this system was used in which the total displacement was measured by the amount of overflow produced by the addition of the fish. That is, the fish, minus surplus water removed by draining, were dumped into a large container filled with water and the overflow thus produced was collected and its volume was taken as equal to the volume of fish. Since the accuracy of the results increases with the narrowness of the neck of the container, a can with a constricted neck is desirable. The accuracy may be increased further by a siphon arrangement emptying into a small container equipped with a spout to carry the overflow into a graduated or measuring can as shown in the diagram.

In our experiment we made use of a narrow necked fish distributing can connected by a piece of garden hose to a small tin can provided with a short length of metal pipe soldered into the side. When both containers and the hose were filled with water and adjusted to the proper height, water flowed from the delivery spout until a constant level was attained. The fish to be measured were held in a dip-net until most of the water drained off, then dumped into the large can and the water thus displaced was collected under the delivery spout. By this method we were able to measure the volume of 3500 fingerling trout at one time and without a single casualty.

G. Clifford Carl,
Cowichan Lake Hatchery,
Lake Cowichan, B. C.

REVIEWS

THE USE OF ELECTRICITY IN THE FISHING OF WILD STREAMS
(Die Electrizitat im Dienste der Wildbachfischerei)

By Franz Hager jun., Mining. Osterreich Fischereiwirtschaft, Nummer 7/8, Juli/August, 1934, pp. 1-3.

THE AUTHOR describes the procedure used in fishing a typical Austrian trout stream by means of electricity, this method being neccessitated by a lack of time to employ the ordinary seining and netting methods. Sufficient electric current was obtained from a 3 horse-power Bosch benzine dynamo mounted on a small wagon, which was dragged along the stream-banks during the fishing. The electric current was

conducted to two copper plates (10 inches square) fastened at the ends of long hallow poles. Each pole or electrode is handled by one man so that the electrodes are about 20 to 40 feet apart when placed in the water where fish are seen or where fish are known to be. A 2-volt shock stunned trout up to 18 inches in length.

Stunned trout may be revised in from three to five minutes if they are placed in a live box in flowing water away from the effects of the electrical current. Pike require somewhat longer to recuperate, as they are more easily shocked.

The operating personnel consisted of seven men, two men handle the electrodes, two men net the stunned fish, one man runs the motor, and one man tows a live box where the captured fish are kept. (The seventh individual was evidently a handy man). The author considers the electrical method of fishing as relatively easy where deep water, deadheads, and thick brush do not hinder the handling of the necessary cables.

Advantages claimed for the electrical method of fishing are:

(1) It is a more humane method than the use of seines, bow-nets, gill-nets, floating nets, or hook and line.

(2) Fish captured by the electrical method can be held in captivity longer than those taken by other methods;

(3) It is an economical method;

(4) It is a method which may be used to rid a stream of undesirable species without losing the game fish present.

The electrical method is thought by the author to be worthy of consideration by fisheries researchers because it offers them a means of accurately determining the productivity of different types of wild waters. He warns, however, that the method is not without some danger, and states that researches of this type should not be undertaken without the direction of qualified individuals.

If this electrical method of fishing a stream is as practicable as the author claims, it would be a much faster and more accurate method of conducting stream population studies than any other method now in use. Further experimentation and observation on this method should prove of considerable interest to practical fisheries workers.

David S. Shetter,
Institute for Fisheries Research,
Michigan Department of Conservation.

EXPERIMENTAL MODIFICATION OF THE SEXUAL CYCLE IN TROUT BY CONTROL OF LIGHT

By Earl E. Hoover. Science, Vol. 86, No. 2236, pp. 425-426

Abstract

ALTHOUGH it is well established that the sexual cycle in birds is subject to control by experimental methods, it is believed that the experiment reported herein represents the first attempt to modify the sexual cycle in fish. In this experiment a group of brook trout (Salvelinus fontinalis) belonging to a strain that normally spawns in New Hampshire in October, November, and December were exposed to an artificial light cycle in an effort to discover whether sexual activity in fishes might be influenced by the duration of the daylight period. A 25-watt mazda lamp and a 16 cp. carbon filament lamp, automatically controlled by an electric time switch, were suspended over each aquarium containing experimental fish. Beginning on February 20, 1937, the daily light period was increased gradually one hour per week until eight hours of light had been added to the normal daylight period. The period of illumination was then gradually reduced to the normal day, after which each experimental aquarium was covered for periods increasing in length each week until the equivalent of an eight hour day was produced.

On August 12 all the experimental male fish contained large quantities of spermatozoa and could be stripped in the usual hatchery manner. The first eggs were taken from the female fish on August 31, 1937, approximately 3 months before the usual spawning time of this strain of trout. Control fish kept under similar temperature, food and water conditions (with the exception of light manipulation) showed no evidence of sexual activity at this time.

Although the experiment as performed did not indicate whether the increase or the decrease in the daylight period was the controlling factor, it established the fact that the sexual cycle of fish, like that of birds or mammals, can be manipulated by regulating the length of day.

The practical value of inducing early spawning in rainbow trout by this method lies in the fact that most of the strains of these fish in New Hampshire do not spawn until spring and the fry are too small to plant with any degree of success in the streams by fall, necessitating the expense of carrying the fish through the winter.

R. L. C.

3407

"FISH CONSERVATION ADVANCED IN 1937"

By C. A. French, Commissioner of Fisheries of the State of Pennsylvania. Pennsylvania Angler, Vol. 7, No. 1, January 1938.

Abstract

THE YEAR 1937 has seen the most outstanding progress in fish conservation in Pennsylvania since the organization of the Fish Commission in 1873. Four advances are particularly outstanding:

(1) The vast increase in production of various species of popular game and food fishes by the hatcheries of the Fish Commission. The total distribution of brook, brown, and rainbow trout for the year exceeded 4,667,750 fingerling and legal size trout of the combined species; bass production reached an all-time high with a distribution of 365,434 large and small-mouthed bass; bluegill sunfish and bullhead catfish were produced and stocked in large numbers, the figures for sunfish approaching 750,000.

(2) Enactment by the legislature of a new fish code giving to the Board of Fish Commissioners the power to regulate the season, creel limits, and size limits of various species of fish in keeping with changed conditions. This step is made particularly necessary by the increase in the number of anglers and the decrease in the extent of available fishing waters. Of Pennsylvania's 100,000 miles of waterways, 80,000 are today polluted in varying degrees. The clean waters of the state must bear the brunt of fishing until the new pollution law has had time to clean up polluted waters.

(3) A sharp increase in the number of fishermen by at least 75,000 over the preceding year, brought about through enactment of a law permitting fishing on Sunday.

(4) Completion of a new bass producing project on Spring Creek, Centre County, making possible heavier distribution of bass of both species. This project consists of 28 especially constructed ponds and 25 channels, a large brood pond more than acre in extent, and a tempering basin for the low temperature water taken from Spring Creek. Use of ground fish as food resulted in the growth of young bass to a length of from 3 to 7 inches before their release.

Far more intensive stocking with both trout and warm water fishes should result next year from the allocation of $100,000 for increasing the size of the new Huntsdale hatchery in Cumberland County, a WPA project. Trout at Huntsdale have been known to to attain a length of 12 inches in 12 months, and this hatchery offers the most promising source for increasing fish production of any in the State.

R. L. C.